



Inertia and Friction

DESCRIPTION

This lesson connects a series of activities to examine the relationship between mass, inertia, acceleration, force, friction, and speed.

OBJECTIVES

Students will

- Investigate the relationship between mass, acceleration, and force as described in Newton's second law of motion
- Investigate how varying mass to accelerate an object affects reaction to the force generated
- Explore friction and the effects it has on the speed of a moving vehicle
- Predict how forces work in a "space," or microgravity, environment

NASA SUMMER OF INNOVATION

UNIT

Physical Science—Forces and Motion

GRADE LEVELS

4 – 6

CONNECTION TO CURRICULUM

Science and Mathematics

TEACHER PREPARATION TIME

60 minutes

LESSON TIME NEEDED

2.5 Hours

Complexity- Moderate

NATIONAL STANDARDS

National Science Education Standards (NSTA)

Science as Inquiry

- Abilities necessary to do scientific inquiry

Physical Science

- Position and motion of objects
- Motions and forces
- Properties of objects and materials

Science and Technology

- Abilities of technological design
- Understanding about science and technology

Common Core State Standards for Mathematics (NCTM)

Numbers and Operations in Base Ten

- Generalize place value understanding for multi-digit whole numbers
- Use place value understanding and properties of operations to perform multi-digit arithmetic

Measurement and Data

- Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit
- Represent and interpret data

Geometry

- Graph points on the coordinate plane to solve real-world and mathematical problems

MANAGEMENT

The activities in this lesson should be done with cooperative groups of two to three students. Safety practices should be reviewed and observed during the activities.

CONTENT RESEARCH

Review the background information included with each activity. Review and discuss information with students to ensure understanding to allow students to explore the data results and explain their answers and outcomes. The NASA Rockets – Educator Guide has great background information on rockets and their history. The guide also discusses Newton's Laws of Motion very clearly.

<http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html>

Key Concepts:

- Gravity extends over all space
- Weightlessness is a result of free fall
- Orbital motion is a form of free fall

Key terms:

- Newton's 1st Law of Motion: Objects at rest remain at rest and objects in motion remain in motion in a straight line unless acted upon by an unbalanced force
- Newton's Second Law of Motion: The second law relates force, acceleration, and mass: $f = m \times a$. The force produced on the Newton car is directly proportional to the mass of the expelled bottle times its acceleration
- Force: a push or a pull exerted on an object
- Mass: the amount of matter contained in an object
- Acceleration: change in speed or direction of an object
- Friction: The interaction of the surface of one body against that of another causing a slowing of motion
- Microgravity: An environment that imparts to an object a net acceleration that is small compared to that produced by Earth at its surface

Misconceptions:

- Inertia: The most common misconception is that sustaining motion requires a continued force. (Newton's first law of motion declares that a force is not needed to keep an object in motion.) A book in motion on the tabletop does not come to a rest position because of the *absence* of a force; rather it is the *presence* of a force—friction—that brings the book to a rest position.
- Weightlessness: Most people think that objects (and astronauts) in orbit are weightless (or float) because there is no gravity there. (Weightlessness arises from orbital motion, not from diminished gravity and not from being above the Earth's atmosphere (another common misconception))

A great article explaining misconceptions about weightlessness and microgravity:

www.lcurve.org/writings/PT-WeightlessnessAndMicrogravity.pdf

MATERIALS

Newton Car

- One 1- by 3- by 8-inch board
- Three ¼-in.-diameter by 2 ½-in. dowels (or wood screws)
- Wood glue
- Cotton string
- Two rubber bands (size 19)
- Medicine bottles
- 25 straight drinking straws (not flex)
- Meter stick or ruler
- Metric beam balance or scale
- Scissors or lighters
- Popcorn seeds, washers, pennies, paper clips, etc.
- Safety goggles

Racing Against Friction

- Large sheets of corrugated cardboard
- Masking tape
- Felt fabric
- Wax paper
- Sandpaper
- Construction paper
- Various textbooks
- Small toy cars
- Stop watches
- Student Sheets
- Scissors

LESSON ACTIVITIES

Newton Car

Student teams use a wooden car and add rubber bands to toss a small mass off a car resting on rollers, propelling the car in the opposite direction. The team will vary the mass and number of rubber bands, in a number of experiments, to measure how far the car rolls in response to the force.

http://www.nasa.gov/pdf/153412main_Rockets_Newton_Car.pdf

Racing Against Friction

Working in space can be tricky. With no apparent gravity or friction to keep things in place, relatively simple tasks can become complicated ordeals. To prepare for the rigors of working in space, astronauts train in many different facilities on Earth. One of these facilities, the Precision Air Bearing Facility at Johnson Space Center in Houston, Texas, is used to simulate the reduced friction found in space. This lesson will introduce students to the concept of friction being a slowing force.

http://www.nasa.gov/pdf/265386main_Adventures_In_Rocket_Science.pdf

ADDITIONAL RESOURCES

- This video introduces students to Isaac Newton's Laws of Motion and demonstrates how they apply to space flight. Using the microgravity environment of Earth orbit, space shuttle astronauts conduct simple force and motion demonstrations in ways not possible on Earth.

<http://quest.nasa.gov/space/teachers/liftoff/newton.html>

- More on Newton's Laws from NASA Web site:

<http://www.grc.nasa.gov/WWW/K-12/UEET/StudentSite/dynamicsofflight.html#lawofmotion>

DISCUSSION QUESTIONS

- How would the Newton Car used in the first activity react with similar tests done in the weightless environment of the space station? *Newton's laws of motion would still govern the movement of the bottle and the car, but the movements would be somewhat multiplied as the objects would be floating.*
- What would be the effect of weightlessness on the friction experiments in the second activity? *In the weightless environment of the space station, the friction between surfaces would be greatly reduced or non-existent.*
- NASA activity includes additional discussion questions in the provided Student Data components.

ASSESSMENT ACTIVITIES

- Review experiment report for completeness and check team statements, explaining the relationship between mass, acceleration, and the distances the cars traveled.
- Ask students for other examples of Newton's laws of motion at work.

ENRICHMENT

Each activity includes extensions to allow students to continue their learning experiences. Study Isaac Newton's Laws of Motion.